Global air pollution as a climate forcing at 2030

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Abstract

We apply the GISS chemistry-climate model to simulate tropospheric composition (CH_4, O_3, SO_4) at 2030 via a time-slice approach. We compare 4 different anthropogenic emissions forecasts: A1B, B1 from IPCC SRES and Current Legislation (CLE) and Maximum Feasible Reduction (MFR) from the International Institute for Applied Systems Analysis (IIASA). The projections encompass a wide range of possible anthropogenic emissions changes (Figure 1). Each emissions projection was run with both a fixed present day climate and a future 2030 climate (previously generated using a coupled ocean-atmosphere model). For the CLE and B1 scenarios, the impacts of physical climate changes on composition are of comparable magnitude to the emissions changes, whereas A1B and MFR are largely dominated by the anthropogenic emissions changes. We find only small increases in natural climate-sensitive emissions at 2030 (about 5% increase in CH_4 emissions from wetlands and NO_x from lightning, and less than 1% in oceanic DMS emissions).

We present resultant global mean radiative forcings at 2030 relative to the present day for each species: CH_4 = +0.26 to -0.02 W/m^2; O_3 = +0.19 to -0.01 W/m^2; SO_4 = -0.24 to +0.18 W/m^2 (Figure 2)· For A1B the forcings are as much as ½ of that of the preindustrial to present day forcing. For MFR, the sign of the forcings for each species is reversed. However, for all examined future scenarios the combined sum of the CH_4, O_3 and SO_4 forcings is positive. Inclusion of feedbacks from climate change dampens the forcings of all components, 5-20% for CH_4, and up to 60-80% for O_3 and SO_4. Regionally and seasonally, the O_3 and SO_4 forcings may be much larger, for example for the A1B scenario in NH summer, the zonal mean forcings at 0-30°N are: O_3 = +0.27 W/m^2 and SO_4 = -0.82 W/m^2.

The A1B, B1 and CLE projections all suggest large increases in ground level O_3 and SO_4 pollution at tropical and subtropical latitudes (0-30°N), especially over the Indian subcontinent where the pollution increases may be as large as 100%. The CLE and B1 scenarios predict very small changes to ground level pollution over the United States and Europe at 2030 (< 5%). The ranges of annual mean ground level O_3 and SO_4 changes across all scenarios are –10 to +30 ppbv and –1200 to +3000 pptv, respectively. Physical climate changes dampen future ground level O_3, but tend to increase ground level SO_4 through an enhancement of dry and wet oxidation rates.

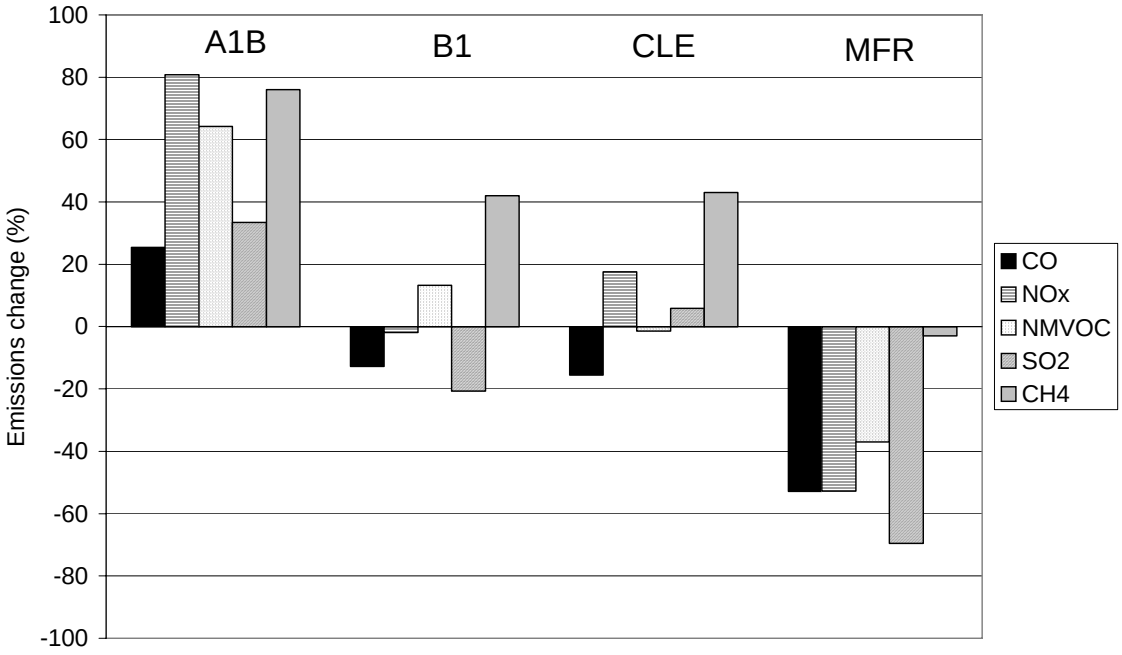

Figure 1. Percent change in global anthropogenic emissions of precursor species at 2030 relative to present day for each projection.

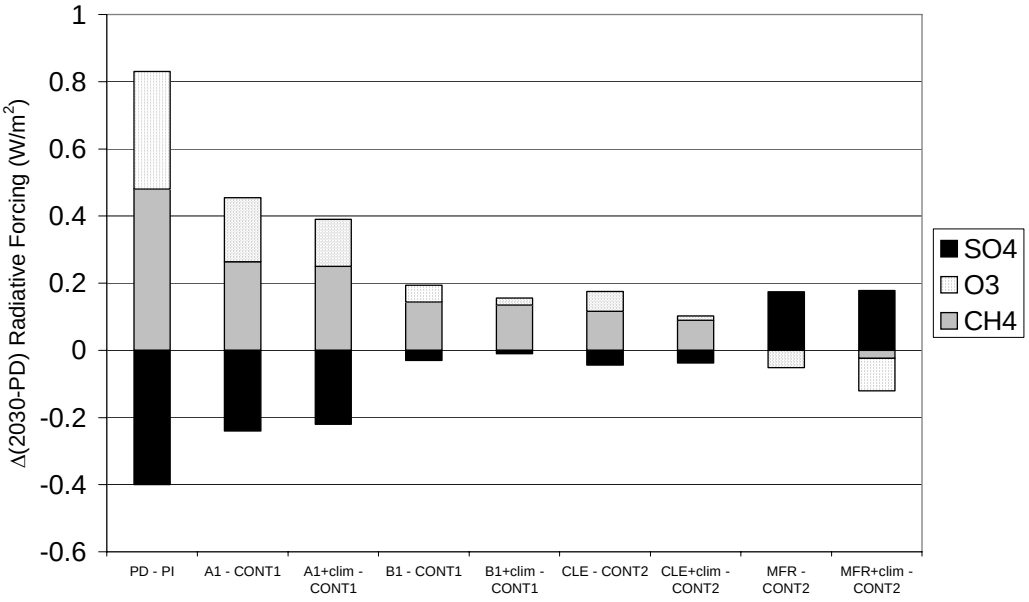

Figure 2. Radiative forcings of CH_4, O_3 and SO_4 aerosol at 2030 relative to present day